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UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Fish and Wildlife Technical Report 26
Washington, D.C. • 1990

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ABSTRACT.—Between 1975 and 1985, the abundance, distribution, and productivity of a raptor population represented by 18 species were monitored on a study area along the Montana–Wyoming border. Nesting by golden eagles (*Aquila chrysaetos*) and bald eagles (*Haliaeetus leucocephalus*) increased during the period. Annual fluctuations in nest site occupancy and productivity seemed to be influenced by available food resources and weather. Poor nesting success of golden eagles, red-tailed hawks (*Buteo jamaicensis*), and great horned owls (*Bubo virginianus*) was associated with a major decline in cottontails (*Sylvilagus* spp.) in 1984 and 1985. The importance of specific territories to recruitment was particularly evident with golden eagles. Pairs on some territories successfully fledged young at consistently high rates, while others were poor producers. Fifty-nine percent of raptor nests were found in ponderosa pines (*Pinus ponderosa*). Deciduous trees, cliffs, and man-made structures were used to a lesser degree. Some interspecific competition for nest sites was noted.

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Birds of prey, like many other groups of wildlife, are sensitive to environmental change, especially to alteration of their nesting habitat. Habitat losses have accounted for population declines and range reductions of several species. Increased cultivation of native grasslands in Saskatchewan, Manitoba, and Alberta, Canada, has reduced the number of nesting ferruginous hawks (*Buteo regalis*; Nero and Wrigley 1977; Houston 1979; Schmutz 1984). Brown (1964) documented the decline of the red-shouldered hawk (*B. lineatus*) resulting from the clearing of woodlots and bottomland hardwoods in Iowa. A decline in golden eagle (*Aquila chrysaetos*) nesting activity along the Colorado Front Range was attributed to accelerated commercial and urban development (Boeker 1974). Craighead and Mindell (1981) attributed the decline of several nesting Wyoming raptors to increased disturbance from human activity and to changes in the natural environment of Grand Teton National Park from 1947 through 1978.

Fossil fuel mining during the 1970's posed threats to raptors inhabiting the Northern Great Plains region by potentially disturbing an estimated 293,401 ha of habitat (Anonymous 1975). When large surface coal mines in Montana, North Dakota, and Wyoming were developed, several habitat types were altered.The effect of this activity on local populations of nesting raptors was unknown.

In 1975 the U.S. Fish and Wildlife Service, in cooperation with the Kiewit Mining Group, Inc., initiated an investigation to determine the distribution, abundance, and habitat relations of nesting raptors on a large tract of land being considered for intensive coal development in southeastern Montana and northern Wyoming. This information was needed by resource managers to provide the necessary legal habitat protection measures during the coal planning process. Land management recommendations were to be developed based on the findings. This paper reports and summarizes the information gathered on 18 species of nesting raptors over the 11-year period, 1975–85 (Table 1).

Study Area

The 863-km^2 study area was located along the southeastern Montana and northern Wyoming border (Fig. 1). Elevations range from 1,036 m at the eastern boundary to 1,500 m in the Wolf Mountains to the west. The area is characterized by rolling hills and benches covered with big sagebrush (*Artemisia tridentata*) and grasses. The Tongue River flows from south to north through the area. Vegetation along the major drainages is a mixture of deciduous trees and shrubs, riparian grassland, and irrigated hayfields.

Common tree species in the riparian areas include plains cottonwood (*Populus deltoides*), green ash (*Fraxinus pennsylvanica*), and boxelder (*Acer negundo*). Stands of ponderosa pine (*Pinus ponderosa*) and Rocky Mountain juniper (*Juniperus scopulorum*) are found on rocky, north slopes; scattered groves of quaking aspen (*Populus tremuloides*) occur along higher elevation draws. Sandstone outcrops are scattered throughout the area.

Prey species in the area include cottontails (*Sylvilagus* spp.; Fig. 2), black-tailed prairie dogs (*Cynomys ludovicianus*; Fig. 3), and numerous other small mammals, birds, and reptiles.

This study area was selected because it is representative of the vegetation and topography found in the coal-rich Powder River Basin. Four coal surface mines operate in the area, and proposals for further coal development are under consideration (Fig. 4).

Methods

Intensive ground and aerial surveys were conducted during the breeding season (February–August) to locate rap-

Table 1. *Species and number of raptor pairs found in a portion of northern Sheridan County, Wyoming, and southeastern Big Horn County, Montana, 1975–85. (Scientific names of species are given in text.)*

Species	Number of breeding pairs[a]	Years nesting data recorded
Turkey vulture	2	1975–85
Osprey	2	1975–85
Cooper's hawk	8	1976–83
Northern goshawk	1	1976–78
Golden eagle	30	1975–85
Red-tailed hawk	46	1975–85
Swainson's hawk	3	1976–81
Northern harrier	13	1975–85
Bald eagle	1	1983–85
Merlin	1	1984
Prairie falcon	7	1975–85
American kestrel	80	1975–85
Northern saw-whet owl	1	1981–83
Short-eared owl	3	1979–83
Long-eared owl	5	1976–83
Burrowing owl	2	1978–84
Great horned owl	38	1976–85
Eastern screech-owl	1	1981–83

[a] Maximum number of pairs recorded on the study area in a particular year.

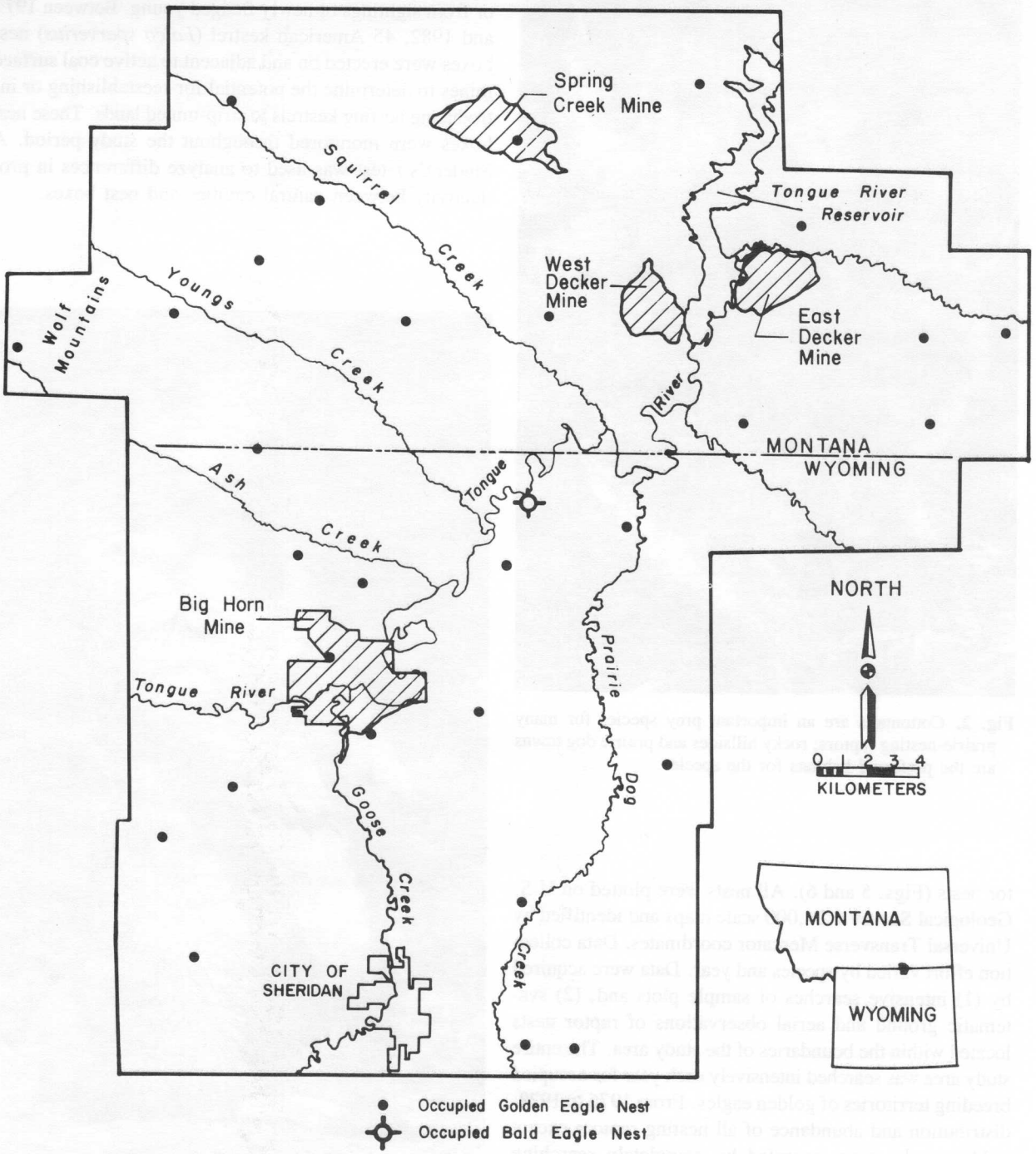

Fig. 1. Location of study area showing the distribution of occupied golden eagle and bald eagle nests in 1985.

Fig. 2. Cottontails are an important prey species for many prairie-nesting raptors; rocky hillsides and prairie dog towns are the preferred habitats for the species.

tor nests (Figs. 5 and 6). All nests were plotted on U.S. Geological Survey 1:24,000 scale maps and identified by Universal Transverse Mercator coordinates. Data collection effort varied by species and year. Data were acquired by (1) intensive searches of sample plots and, (2) systematic ground and aerial observations of raptor nests located within the boundaries of the study area. The entire study area was searched intensively each year for occupied breeding territories of golden eagles. From 1976 to 1978, distribution and abundance of all nesting raptors except golden eagles were sampled by completely searching 25 2.59-km^2 survey plots that were subjectively located in representative habitat types throughout the study area. In 1975, and from 1979 to 1985, the survey plots were not searched, but data were collected on a sample of nests located within the study area boundaries. For some species, such as the small owls, all nests were not found, but breeding activity was determined from vocalizations or from sightings of newly fledged young. Between 1977 and 1982, 45 American kestrel (*Falco sparverius*) nest boxes were erected on and adjacent to active coal surface mines to determine the potential for reestablishing or introducing nesting kestrels to strip-mined lands. These nest boxes were monitored throughout the study period. A Student's t-test was used to analyze differences in productivity between natural cavities and nest boxes.

Fig. 3. Black-tailed prairie dogs are scattered throughout the study area; their colonies provide a stable food supply for golden eagles much of the year.

Fig. 4. Aerial view of East Decker and West Decker coal surface mines in the spring of 1984 with the Tongue River Reservoir between them.

The annual abundance of cottontails was determined from counts conducted along 36.8 km of road during each July and August (Lord 1963). The correlation coefficient (r) was calculated to estimate the level and direction of the relation between cottontail abundance and the number of young fledged per occupied nest per year. Terminology used to describe reproductive parameters and nest status generally follows the definitions of Postupalsky (1974) and Steenhof (1987). To avoid semantic confusion, the terms used in this paper are described as follows:

Nest or eyrie A structure built or occupied by raptors for the purpose of rearing young.

Occupied breeding territory An area containing a nest or group of nests associated with the breeding activities of a single mated pair of raptors.

Occupied nest A nest within an occupied territory that has been repaired or tended in a given year by a pair of raptors; by definition there is only one occupied nest per territory even though alternate nests may be tended.

Nesting success Proportion of pairs in occupied breeding territories (for which the outcome of nesting is known) that produces at least one young to 80% of the average age when most young normally fledge.

Fig. 5. A tandem-seated, fixed-wing aircraft was used for most aerial survey work; it is shown here over ponderosa pine nesting habitat, where golden eagle nesting density was greatest.

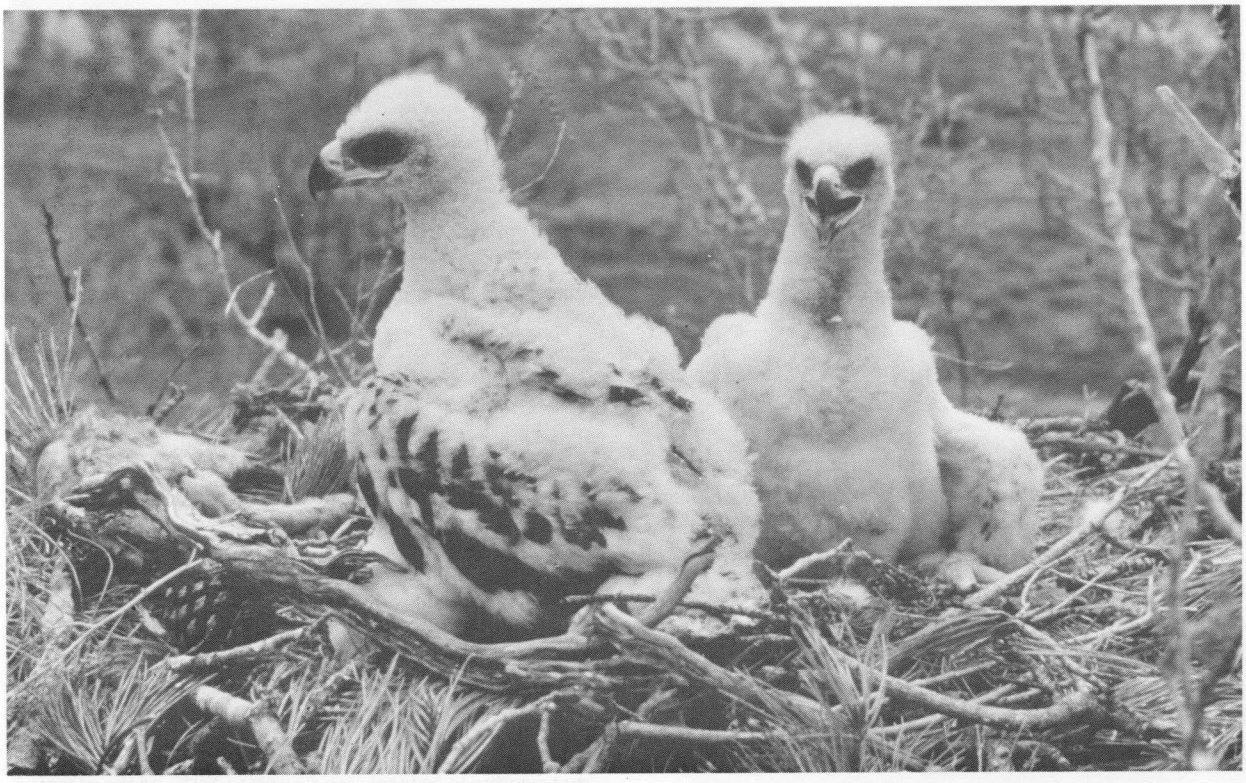

Fig. 6. Golden eagle nest with two young; downy eaglets were easily counted during annual productivity surveys.

Results and Discussion

Distribution, Abundance, and Reproductive Performance

Golden Eagles

Golden eagle nests were typically found in large trees in the bottom of isolated drainages. Seventy percent of the nests were in live ponderosa pines, 18% in cottonwoods, 8% in pine snags, and 4% on other substrates (cliffs or rock ledges). Nests were usually found in the upper one-third of a tree where two or more lateral branches extended from the trunk to form a platform. The number of alternate nests maintained by a single pair varied from 0 to 3, and averaged 1.7 alternate nests per pair. Distances between alternate nests of individual pairs varied from 0 (same tree) to 3.4 km.

The number of occupied golden eagle territories monitored within the study area varied from 10 in 1975 to 30 in 1985. Occupied nests were distributed throughout the study area (Fig. 1). Several factors contributed to the increase in the number of pairs during the study: (1) the size of the survey area was enlarged in 1976 and 1981; (2) the investigators became increasingly familiar with the area and its resident eagle population; and (3) real growth in the breeding population. After 8 years of nest surveys, we believed that the study area was saturated with a breeding population of 26 resident eagle pairs. However, in 1983, two new pairs established territories, followed by a third pair in 1984, and a fourth in 1985. Establishment of new breeding territories on the study area between 1981 and 1985 resulted in a density increase from one pair per 36 km^2 to one pair per 28.7 km^2. Density of breeding eagles on our study area is high when compared with other eagle populations in the western United States (Phillips et al. 1984). The distance between adjacent occupied nests varied from 1.7 to 7.3 km ($\bar{x}$ = 4.4 km; SD = 1.5; n = 30; Fig. 7).

Increases in numbers of eagles on the study area came during years of abundant prey. Despite a severe decline in the cottontail population during the 1983–84 winter, all resident eagle pairs continued to occupy territories during the 1984 and 1985 breeding seasons. Once a breeding territory was occupied, it was not abandoned throughout the 11 years of study. Similar general population stability for golden eagles was noted in Scotland by Brown and Watson (1964).

Nesting success for this eagle population varied from 30% to 90% ($\bar{x}$ = 54%) over the 11-year period (Table 2). Success rates for 24 individual pairs (monitored for at least five breeding seasons) occupying specific territories varied from 18% to 91% and averaged 55%.

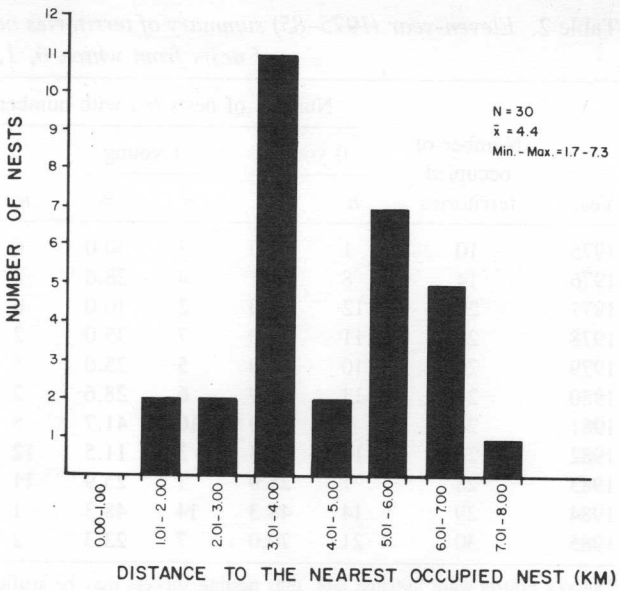

Fig. 7. Spatial distribution of occupied golden eagle nests on the study area in 1985.

Eagles at one territory successfully fledged young 10 of 11 years while a different pair fledged young only 1 of 9 nesting seasons. The pattern of nesting success for all other pairs was more irregular (Table 3).

Certain breeding territories and their associated pairs were more important than others in producing young. Some pairs were consistent producers, whereas others only occasionally fledged young. When we compared only territories for which 5 or more years of data were gathered, the mean number of young produced by pairs on a particular territory varied from 0.18 to 1.60 per year. The lack of mortality data makes it difficult to assess the level of recruitment required for golden eagle population stability. Reproduction by pairs showing the lowest rates (0.11–0.40) would seem inadequate to ensure replacement. However, the 11-year average of 0.78 young fledged per pair per year is identical to the combined average for 5 golden eagle populations reported elsewhere (Table 4).

Productivity of specific pairs was likely controlled by variables such as age and behavior of the pair, security and physical stability of the nest, and proximity to a stable and available food source (Newton 1979). It was often difficult to determine the exact cause of nest failure on the study area, but adverse weather conditions played a major role in nesting losses. High winds accompanied by wet snow and rain destroyed several nests and caused many reproductive failures throughout the study period.

Table 2. *Eleven-year (1975–85) summary of territories occupied by golden eagles; nesting success and the number of nests from which 0, 1, 2, or 3 eaglets fledged.*

Year	Number of occupied territories	Number of nests (*n*) with number of young fledging								Number of young per successful nest	Nesting success (%)
		0 young		1 young		2 young		3 young			
		n	%	*n*	%	*n*	%	*n*	%		
1975	10	1	10.0	3	30.0	6	60.0	0	0	1.7	90[a]
1976	14	8	57.1	4	28.6	2	14.3	0	0	1.3	43
1977	20	12	60.0	2	10.0	6	30.0	0	0	1.8	40
1978	20	11	55.0	7	35.0	2	10.0	0	0	1.2	45
1979	20	10	50.0	5	25.0	5	25.0	0	0	1.5	50
1980	21	13	61.9	6	28.6	2	9.5	0	0	1.3	38
1981	24	6	25.0	10	41.7	8	33.3	0	0	1.4	75
1982	26	11	42.3	3	11.5	12	46.2	0	0	1.8	58
1983	28	7	25.9	7	25.9	11	40.8	2	7.4	1.8	74[b]
1984	29	14	48.3	14	48.3	1	3.4	0	0	1.1	52
1985	30	21	70.0	7	23.3	2	6.7	0	0	1.2	30

[a]Survey efforts were initiated late, thus nesting success may be artificially high.
[b]One territory was not checked for productivity this year.

Table 3. *Reproductive history of golden eagle territories within the southeastern Montana and northern Wyoming study area, 1975–85.*

Territory	Year of record											Success[a] (%)
	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	
1	P[b]	P	P	P	P	NP	P	P	P	P	P	91
2	P	P	P	NP	P	P	P	P	P	NP	NP	73
3	P	NP	NP	P	NP	P	P	P	P	NP	NP	55
4	P	NP	NP	NP	NP	NP	NP	P	P	P	NP	36
5	P	P	NP	P	P	NP	P	P	P	P	NP	73
6	NP	NP	NP	NP	NP	NP	NP	NP	P	P	NP	18
7	P	NP	P	NP	NP	NP	P	NP	NP	P	NP	36
8	P	NP	P	NP	NP	NP	P	P	P	NP	NP	45
9	P	P	NP	P	P	NP	P	NP	P	NP	NP	55
10	P	NP	NP	P	P	P	NP	P	P	NP	NP	55
11	*	P	NP	NP	P	P	P	NP	P	NP	P	60
12	*	NP	P	NP	NP	NP	P	NP	NP	NP	NP	20
13	*	P	P	P	NP	P	NP	P	P	NP	NP	60
14	*	*	P	NP	P	NP	P	P	P	NP	P	67
15	*	*	P	NP	P	NP	NP	NP	P	P	NP	44
16	*	*	NP	NP	NP	P	NP	NP	NP	NP	P	22
17	*	*	NP	P	NP	NP	P	NP	P	P	NP	44
18	*	*	NP	P	P	NP	P	P	P	NP	NP	56
19	*	NP	NP	NP	P	P	P	P	*	P	NP	56
20	*	*	NP	P	NP	NP	P	NP	P	P	NP	44
21	*	*	*	*	*	P	P	P	P	P	NP	83
22	*	*	*	*	*	*	P	NP	NP	P	P	60
23	*	*	*	*	*	*	P	P	NP	P	P	80
24	*	*	*	*	*	*	P	P	P	P	NP	80
25	*	*	*	*	*	*	*	P	P	NP	NP	50
26	*	*	*	*	*	*	*	NP	P	P	P	75

Table 3. *Continued.*

Territory	Year of record											Success[a] (%)
	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	
27	—	—	—	—	—	—	—	—	NP	NP	NP	0
28	—	—	—	—	—	—	—	—	NP	NP	P	33
29	—	—	—	—	—	—	—	—	—	P	NP	50
30	—	—	—	—	—	—	—	—	—	—	P	100

[a]Percent success is defined as the number of years the territory was productive divided by the number of years monitored.
[b]P = productive; NP = not productive; * = no information; — = no known territory in existence.

Table 4. *Comparison of reproductive success for six golden eagle populations.*

Study area	Number of pairs monitored	Years of study	Number of young fledged per pair per year	Source
Southwestern Idaho	50–55	7	0.75	USDI (1979)
Utah	16	6	0.69	Murphy (1975)
Scotland	5	13	0.80	Watson (1957)
Southwestern Wyoming	10–17	7	0.83	S. Platt (Wyoming Department of Land Quality, personal communication)
Northeastern Wyoming	85–140	5	0.81	Phillips and Beske (1990)
Southeastern Montana–northern Wyoming	10–30	11	0.78	This study

The effect of weather on nesting success was exemplified during the 1984 nesting season when 71% (10 of 14) of the nests having chicks before a storm failed after a 3-day (26–28 April) blizzard.

Eagles fledge one to three young per successful nest, but the number varies from area to area and from year to year (Brown 1977; U.S. Department of the Interior 1979). The annual number of young fledged per successful nest on our study area averaged 1.3 for the 11-year period (min–max = 1.1–1.8; SD = 0.3; n = 11 years). The fledging rates for all pairs monitored on the study area are shown in Table 2. Our observed rates were similar to the 1.4 and 1.5 young per successful nest reported for southwestern Idaho and northeastern Wyoming, respectively (U.S. Department of the Interior 1979; Phillips and Beske, Denver Wildlife Research Center, unpublished report).

The relation between reproductive success and prey abundance was difficult to evaluate because we were unable to measure annual changes for all species that composed the diverse prey base of the study area. Eagle food habits data collected at four nests in 1977 showed that prairie dogs and cottontails represented 65.7 and 14.4%, respectively, of the biomass brought to the nests. Study area eagles also fed on a wide variety of other mammals, birds, and reptiles (J. M. Lockhart, T. P. McEneaney, and A. L. Harting, Jr., Denver Wildlife Research Center, unpublished report).

Prairie dogs were not uniformly distributed throughout the study area; hence, were unavailable as a food source for all eagle pairs. However, cottontails were widely distributed and available to all study area eagles. Annual roadside counts suggested that cottontail numbers fluctuated widely over the 11-year period (Fig. 8). Two golden eagle broods had three young each in 1983, the only year of triplets; this coincided with peak cottontail abundance. Jenkins and Joseph (1985) reported on the normally low occurrence of triplets in western golden eagle populations, and pointed out that a higher than normal frequency of triplets is probably related to increased prey availability. The number of young fledged per pair and cottontail abundance were correlated (r = 0.80; $P \leq .05$; n = 7; 1975 data were not included in the analysis). Similar relations have been noted between golden eagle reproduction and the abundance of black-tailed jackrabbits (*Lepus californicus*) in Utah (Murphy 1975) and

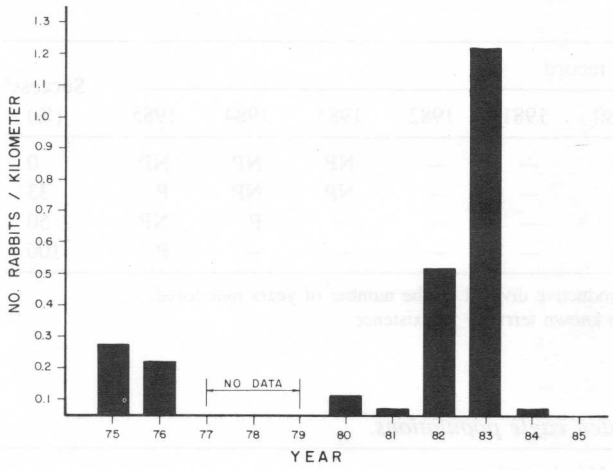

Fig. 8. Comparison of roadside cottontail counts in southeastern Montana and northern Wyoming, 1975–85.

southwestern Idaho (U.S. Department of the Interior 1979).

We attribute weather and prey abundance as the primary factors that affected golden eagle nesting success and productivity on our study area. The abundance of prey probably influences both the total number of successful breeding pairs during a particular year and the number of young fledged per successful nest. Strong winds, wet snow, and cold rain depressed nesting success regardless of prey abundance.

Red-tailed Hawks

Red-tailed hawks (*Buteo jamaicensis*) nested in several habitats, but nests were most numerous in riparian zones. Upland draws with adjacent grassland or agricultural tracts were also commonly used. The mean distance between occupied nests was 2.4 km (SD = 0.85, n = 28).

Red-tailed hawk nesting occurred in coniferous (51%) and deciduous trees (44%; Table 5). Although pairs had as many as three alternate nests, usually only one nest was repaired during a breeding season. The same nests were often used yearly by red-tailed hawks unless the nests were preempted by an earlier nesting species.

Nesting success of red-tailed hawks fluctuated over the 11-year period (min–max = 14–85%; $\bar{x}$ = 70%). The lowest reproductive success occurred in 1985 when cottontail numbers were low (Fig. 8). No cottontails were observed during August 1985 roadside counts. Petersen (1979) also noted reduced breeding activity for Wisconsin red-tailed hawks in years when rabbit populations were low. The number of young fledged per successful pair averaged 2.0 (min–max = 1.5–2.5; SD = 0.32; n = 10 years). These findings are similar to those reported by Gates (1972) for Wisconsin and by Johnson (1975) for southwestern Montana.

Prairie Falcons

All prairie falcon (*Falco mexicanus*) eyries found on the study area were in cracks and potholes in sandstone cliffs. Some eyries were occupied in successive years while others were used irregularly. No group of cliffs was occupied by more than one pair during any given breeding season. Distances between occupied eyries averaged 7.8 km (min–max = 2.4–20.2 km; SD = 8.9; n = 7). We attributed this spatial distribution to the short segments of sandstone outcrops on the study area.

Prairie falcons were not abundant on our study area, possibly because of the limited number of suitable nesting cliffs. At most, seven territories were occupied in several different years. Reproductive success for this species was fairly consistent, averaging 79% (min–max = 50–100%). The number of young fledged averaged 3.5 per successful nest (min–max = 1.8–5.0; SD = 0.85; n = 11 years). Our prairie falcon reproductive variables are comparable to those reported by other investigators (U.S. Department of the Interior 1979; Becker and Ball 1983).

American Kestrels

Kestrels were the most abundant raptor in the study area. Most nests were in cavities of ponderosa pines and cottonwoods or in sandstone cliffs. Other nests were in fence posts, under bridges, and in magpie nests. The greatest number were found in ponderosa pine stands. The mean distance between occupied nest sites on the survey plots was 0.7 km (SD = 0.37; n = 37).

Kestrels using natural cavities were monitored for productivity during 1976–78, and thereafter only pairs using nest boxes were monitored. Nesting success for pairs using natural cavities averaged 92.7% (min–max = 88–100%). Pairs using nest boxes during 1977–85 had a comparable nesting success of 89.3%. However, the number of young kestrels fledged from artificial nesting structures ($\bar{x}$ = 4.3) was significantly greater ($P \leq .01$) than the number of young fledged from natural cavities ($\bar{x}$ = 3.2). Differences might be attributed to the limitations of space in natural tree cavities. We are of the opinion, based on our field observations, that clutch sizes are smaller and mortality of young is higher in natural cavities.

Great Horned Owls

Great horned owls (*Bubo virginianus*) typically nested in vacant red-tailed hawk nests, but were also found in hollow trees, cliff potholes, old buildings, mining cuts,

Table 5. *Nesting habitats used by 15 raptor species in southeastern Montana and northern Wyoming, 1975–85. Number (% rounded) of nests is shown.*

Species	Ponderosa pine	Aspen	Other deciduous trees	Cliff	Ground	Other[a]	Total nests
Turkey vulture					2(100)		2
Osprey			1(33)			2(67)	3
Cooper's hawk	8(67)	4(33)					12
Northern goshawk	5(100)						5
Golden eagle	40(78)		9(18)	2(4)			51
Red-tailed hawk	68(51)	4(3)	58(44)	2(2)		1(1)	133
Swainson's hawk			4(100)				4
Northern harrier					13(100)		13
Bald eagle			2(100)				2
Merlin	1(100)						1
Prairie falcon				8(100)			8
American kestrel	84(58)		3(2)	14(10)		45(31)	146
Short-eared owl					5(100)		5
Long-eared owl	4(57)	2(29)		1(14)			7
Great horned owl	10(18)	1(2)	32(57)	11(20)		2(4)	56
Total	220(49)	11(3)	109(24)	38(9)	20(5)	50(11)	448

[a] Includes nests on man-made structures.

and black-billed magpie (*Pica pica*) nests. In terms of nest site use, great horned owls were the most versatile raptor on the study area. Mean distance between occupied nests was 2.4 km (SD = 1.07; n = 21).

Owls were abundant on the study area, but the number of territories fluctuated annually. Fluctuations were most likely due to changes in food supply. For example, in 1978, 39 territories were occupied compared with 4 in 1985. Also, 81% (17 of 21) of the occupied breeding territories found in 1983 were vacant during the 1985 breeding season. Lack of cottontail rabbits in 1985 (Fig. 8) was probably the major factor accounting for fewer occupied great horned owl territories. Petersen (1979) and Rusch et al. (1972) also noted reduced numbers of great horned owls when rabbits were scarce in Wisconsin and Canada, respectively.

We collected productivity data from a sample of monitored pairs (n = 3–32) each year except 1979. Mean nesting success in most years was high for this species, averaging 84.7% (min–max = 50–100%). The number of young fledged per successful nest averaged 2.0 (min–max = 1.4–2.6; SD = 0.37; n = 9 years). Adverse wet spring weather and the poor structural condition of nests probably accounted for most nest failures and nesting mortality.

Other Raptors

Thirteen other species of raptors, including the turkey vulture (*Cathartes aura*), osprey (*Pandion haliaetus*), Cooper's hawk (*Accipiter cooperii*), northern goshawk (*A. gentilis*), Swainson's hawk (*Buteo swainsoni*), northern harrier (*Circus cyaneus*), bald eagle (*Haliaeetus leucocephalus*), merlin (*Falco columbarius*), northern saw-whet owl (*Aegolius acadicus*), short-eared owl (*Asio flammeus*), long-eared owl (*Asio otus*), burrowing owl (*Athene cunicularia*), and western screech-owl (*Otus kennicottii*), distributed their nesting among the study area habitats (Table 5).

Many nonbreeding turkey vultures were summer residents, but only two pairs were known to breed. Two nests were on steep hillsides at the base of small rock outcrops.

A pair of ospreys nested at the upper end of Tongue River Reservoir throughout the study period. Their nest was in a dead cottonwood until 1983 when the pair shifted to a nesting platform that had been constructed for their use.

One northern goshawk nest was found in a dense stand of ponderosa pine in the Wolf Mountains. Eight Cooper's hawk territories were documented in thick riparian habitat or in dense stands of pine trees. Swainson's hawks were rare on the area, with a maximum of three pairs nesting in deciduous trees during a given year.

In 1983, a pair of bald eagles established a territory and nested successfully in an enlarged red-tailed hawk nest along the Tongue River. Two years later, a second nest was built by the pair in a live cottonwood 0.6 km from the original nest. Although bald eagles traditionally

wintered along the Tongue River, no previous nesting records were known for the study area.

Seven nesting territories of long-eared owls were found on the area. Nests were in ponderosa pine, aspen, or on cliffs. Two pairs of burrowing owls were also known to occupy territories during the course of this study. Both were associated with small (i.e., approximately 1 ha) prairie dog towns.

Northern harriers, merlins, short-eared owls, saw-whet owls, and screech-owls also were observed as breeding adults rearing young within the study area, but few nest site data were collected.

Habitat Use and Interspecies Relations Among Raptor Species

Approximately one-half (220 of 448) of the nests, representing 8 of the 15 raptor species, were in ponderosa pines (Table 5). The most common raptors were those that had adapted to the widest variety of nesting habitats. Red-tailed hawks, great horned owls, American kestrels, and, to a lesser degree, golden eagles nested in tree stands of different species, size, and density. Cliffs and man-made structures of varying shapes and composition were also used. Deciduous trees, combined as a single category, were found along drainages in the study area and contained 24% (109 of 448) of the nests. Plains cottonwoods, the largest and most common deciduous tree in the study area, were absent in the higher drainages immediately to the east of the Wolf Mountains. Boxelders and green ash often extended beyond the local range of cottonwoods into higher elevation drainages and provided good raptor nesting habitat.

Certain habitat conditions provided exceptions to the generally sparse nesting densities that we observed. Where deciduous trees along watercourses were densely grouped, direct line-of-sight was interrupted at short intervals, allowing raptors to nest closer to each other without conflict. Canada geese (*Branta canadensis*) were frequently observed using nests built by osprey, red-tailed hawks, and bald eagles. Raptors often nested in proximity along undulating cliff lines. Great horned owls, prairie falcons, and American kestrels were found nesting within 350 m of each other along sandstone cliffs. Again, direct line-of-sight was blocked between nest sites.

Accipiters were also limited to specific habitat types but were uncommon residents of the study area. Northern goshawks nested at the eastern edge of the Wolf Mountains where higher elevations and more mesic conditions promote dense stands of pines. Nesting Cooper's hawks were generally restricted to portions of the study area where aspens and denser stands of pines occurred.

Red-tailed hawks and great horned owls commonly nested in deciduous tree stands or in upland pine draws, often adjacent to agricultural tracts. The hawk nests, placed in a trunk crotch in the upper one-third of a tree, were usually conspicuous. We noted that red-tailed hawk nests were usually smaller, more symmetrical, and contained less lining material than golden eagle nests.

Two bald eagle nests were in a riparian zone. Bald eagles hunted mostly up and down the river when the waters were open, transecting the territories of many other raptors (golden eagles, red-tailed hawks, prairie falcons, great horned owls, northern harriers, and American kestrels). When the river surface froze completely, fish and ducks were largely unavailable to bald eagles and other raptors. Competition for food, and aggressive behavior, was observed more often. Bald eagles, especially, were forced to hunt and scavenge on upland sites, resulting in interactions and confrontations with other raptors, particularly golden eagles.

American kestrel nests were most commonly found in abandoned woodpecker holes and broken trunks of ponderosa pine snags (83% of the natural eyries located). Cliffs with suitable nesting sites were also used by kestrels. The high occupancy rate for nest boxes (83%) suggested that the kestrel population on the study area may be limited by nest site availability. Although incidence of snags on the study area was high, our observations suggest that few snags had cavities suitable for nesting kestrels. A certain stage of tree decay, at which the heartwood remained somewhat intact, seemed necessary to provide flooring for kestrels at a level 1 m or less below the cavity entrance.

Raptor foraging habitats are selected according to occurrence and vulnerability of prey species. For individual raptor species, certain foraging habitats may be especially important. For example, prairie dog colonies were the most important food source for some golden eagles. For burrowing owls, prairie dog colonies may provide all needs during the breeding season. Raptors, such as short-eared owls, northern harriers, and great horned owls, that feed heavily on small rodents, frequently hunted grassy riparian areas where voles (*Microtus* spp.) were more abundant.

Nesting Habitat and Mining Management

During our 11-year investigation, we did not observe any instances where coal surface-mining activities caused

a reduction in the number of nesting pairs of raptors on the study area. However, there is potential for destruction of nesting habitat as mining activities expand. If this situation occurs, and if alternate nest sites are not already available for a particular raptor pair, an appropriate nest site should be provided (e.g., platform, rock pile, nest box, snag). If mature stands of trees are removed during the mining process, some tree replacement should be attempted during mine reclamation, or some other habitat enhancement practice should be instituted to provide raptor nest sites. Because of the importance of sandstone cliffs as nesting sites, construction of rock outcrops during reclamation or highwall retention should be considered.

Acknowledgments

This project was funded jointly by the U.S. Fish and Wildlife Service, the Kiewit Mining Group, Inc., the Northern Energy and Resources Co., and the Decker Coal Co. Many individuals from these organizations were responsible for locating raptor nests and providing data over the 11-year period. We thank J. Berry, T. Dahmer, L. Halstead-Acharya, B. Harting, D. Heath, M. Humphris, D. Howell, E. Pitcher, B. Stettler, and D. Stine. The special interest and flying expertise of D. Williamson made this a safe and successful study. Special thanks are given to the many ranchers in the Sheridan–Decker area for allowing free access to their lands.

S. Gilbert of OEA Research, Helena, Montana, provided data on cottontail population trends from 1980 to 1985. I. Ferren, F. Powe, J. Randell, and V. Thornsberry showed skill and patience through the paper's many revisions. C. Halvorson, F. Knopf, and K. Steenhof provided editorial assistance and reviewed the manuscript. We thank D. Biggins for his excellent photos and T. Segerstrom for the cover illustration.

References

Anonymous. 1975. Effects of coal development in the northern Great Plains. A review of major issues and consequences at different levels of development. U.S. Department of the Interior, Great Plains Resource Program, Denver, Colo., and Washington, DC. 165 pp.

Becker, D. M., and I. J. Ball. 1983. Prairie falcon (*Falco mexicanus*). Pages 138–153 *in* J. S. Armbruster, ed. Impacts of coal surface mining on 25 migratory bird species of high Federal interest. U.S. Fish Wildl. Serv., FWS/OBS-83-35.

Boeker, E. L. 1974. Status of golden eagle surveys in the western States. Wildl. Soc. Bull. 2:46–49.

Brown, L. 1977. Eagles of the world. Universe Books, New York. 224 pp.

Brown, W. H. 1964. Population changes in red-shouldered and red-tailed hawks. Iowa Bird Life 34:82–87.

Brown, L. H., and A. Watson. 1964. The golden eagle in relation to its food supply. Ibis 106:78–100.

Craighead, F. C., Jr., and D. P. Mindell. 1981. Nesting raptors in western Wyoming, 1947 and 1975. J. Wildl. Manage. 45:865–872.

Gates, J. M. 1972. Red-tailed hawk populations and ecology in east-central Wisconsin. Wilson Bull. 84:421–433.

Houston, C. S. 1979. Ferruginous hawks in Saskatchewan—past and present. Abstract from the Meeting of the American Ornithologists Union, College Station, Tex. 97:7.

Jenkins, M. A., and R. A. Joseph. 1985. 1981—An extraordinary year for golden eagle "triplets" in the central Rocky Mountains. Raptor Res. 18:111–112.

Johnson, S. J. 1975. Productivity of the red-tailed hawk in southwestern Montana. Auk 92:732–736.

Lord, R. D., Jr. 1963. The cottontail rabbit in Illinois. Ill. Dep. Conserv. Tech. Bull. 3. 94 pp.

Murphy, J. R. 1975. Status of a golden eagle population in central Utah. Pages 91–96 *in* J. R. Murphy, C. M. White, and B. E. Harrell, eds. Population status of raptors. Proc. Conf. Raptor Conserv. Tech. Res. Rep. 3.

Nero, R. W., and R. E. Wrigley. 1977. Rare, endangered, and extinct wildlife in Manitoba. Manit. Nat. 18:22.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, S. Dak. 399 pp.

Petersen, L. 1979. Ecology of great horned owls and red-tailed hawks in southeastern Wisconsin. Wisc. Dep. Nat. Resour. Res. Bull. 111. 63 pp.

Phillips, R. L., and A. E. Beske. 1990. Distribution and abundance of golden eagles and other raptors in Campbell and Converse Counties, Wyoming. U.S. Fish Wildl. Serv., Fish Wildl. Tech. Rep. 27. 31 pp.

Phillips, R. L., T. P. McEneaney, and A. E. Beske. 1984. Population densities of breeding golden eagles in Wyoming. Wildl. Soc. Bull. 12:269–273.

Postupalsky, S. 1974. Raptor reproductive success: some problems with methods, criteria, and terminology. Pages 21–31 *in* F. N. Hammerstrom, Jr., B. E. Harrell, and R. R. Olendorff, eds. Management of raptors. Raptor Research Foundation, Vermillion, S. Dak.

Rusch, D. H., E. C. Meslow, P. D. Doerr, and L. B. Keith. 1972. Response of great horned owl populations to changing prey densities. J. Wildl. Manage. 36:282–296.

Schmutz, J. K. 1984. Ferruginous and Swainson's hawk abundance and distribution in relation to land use in southeastern Alberta. J. Wildl. Manage. 48:1180–1187.

Steenhof, K. 1987. Assessing raptor reproductive success and productivity. Pages 157–170 *in* B. A. Giron Pendleton, B. A. Millsap, K. W. Cline, and D. M. Bird, eds. Raptor management techniques manual. Natl. Wildl. Fed., Sci. Tech. Ser. 10.

U.S. Department of the Interior. 1979. Snake River birds of prey special report to the Secretary of Interior. Bureau of Land Management, Boise, Idaho. 142 pp.

Watson, A. 1957. The breeding success of golden eagles in the northeast highlands. Scott. Nat. 69:153–169.